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Building a Laboratory Information Management System Using Windows4GL

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Building a Laboratory Information Management System using CA-Ingres and Windows4GL

by

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Introduction

The system to be discussed in this paper is currently implemented at Lawrence Livermore National Laboratory (LLNL) in the Environmental Services program which operates out of the Chemistry & Materials Science (C&MS) Directorate. Our responsibility has been to provide the C&MS Environmental Services (CES) program with an enterprise-wide information system which will aid CES in achieving its mission. The specific portion of the information system to be described is the Sample Tracking, Analysis and Reporting System (STARS). This system performs the login of both environmental monitoring and hazardous waste samples, tracks completion dates of analyses and samples, provides sample batching, barcoding and tracking of bottles, prepares worklists and worksheets for the chemists, tracks off-site analyses procured through commercial vendors, records the receipt of final sample analysis reports, and prepares a billing file for the finance department at LLNL. The need to manage samples and all related data is integral to CES, hence STARS is an integral part of CES operations.

In May of 1995, CES was formed by merging two analytical laboratory organizations. One of the two organizations had three years previously purchased a commercial Laboratory Information Management System (LIMS) which proved to be completely unsatisfactory. During the same time frame, the other organization had employed us to design and implement a custom LIMS for them, which we built in CA-Ingres and Windows4GL. The newly-formed CES went through an evaluation process addressing whether to buy a commercial system or build a custom system in-house. A prime factor which went into the make-buy decision was weighing the costs involved with purchasing a different commercial product and having it customized to meet the needs of CES versus the costs involved with designing and implementing a new custom system. It would take as long or longer to purchase a commercial product and have it customized and installed than to build a custom product in CA-Ingres and Windows4GL. The expense of each option was comparable. It was also determined that there would be a decreasing probability of success with a commercial product. Another factor in the decision was the disparate experiences the two organizations had with their individual LIMS. The previous commercial product was never satisfactory, nor were the customizations to it. On the other hand, the custom LIMS we built received favorable acceptance. In addition to the LIMS, we had designed and implemented some related Windows4GL applications. These applications were found to be of sufficient value to the organization to be implemented in CES as well. We provided a tracking system for non-conformance and deficiency occurrences, and an analytical instrument calibration and maintenance scheduling application. The management of CES had positive experiences with the above mentioned CA-Ingres and Windows4GL applications and decided that the benefit of the build option outweighed the buy consideration. Management felt the building blocks of hardware, software and expertise were in place to produce a custom product which would meet all of their needs and provide the high level of quality that they expected.

The Application Domain

Lawrence Livermore National Laboratory (LLNL) is a national government research and development laboratory operated by the University of California for the U.S. Department of Energy. LLNL is a national resource, and addresses the nation's technological challenges. As a multidisciplinary laboratory, LLNL has applied its skills in physical sciences, high-performance computing, advanced engineering, and the management of large research and development projects to become the science and technology leader for a wide range of national needs which include:

- environmental problems, such as global climate change
- safety issues, such as large-scale disaster modeling of Chernobyl
- energy research, such as the National Ignition Facility, advanced battery research, and laser fusion
- high-performance computing, such as complex, dynamic simulations ranging from DNA modeling to nuclear explosions

- information infrastructure, such as setting up and managing the National Performance Review on the Internet
- biotechnology, including mapping chromosome 19 in the Human Genome Project
- science education, such as the innovative "Clementine in Cyberspace" project
- national security, including stewardship of our nation's nuclear weapons and nonproliferation
- civilian industrial technologies, ranging from advanced laser applications to electro-optics to pharmaceutical technology transfers
- international collaborations, such as the International Thermonuclear Experimental Reactor.

One of the core scientific competencies at LLNL resides in the Chemistry & Materials Science Directorate (C&MS). C&MS provides cutting-edge expertise in chemistry and materials science to ensure the success of Lawrence Livermore National Laboratory's missions and its related core programs. The directorate anticipates and initiates R&D projects relevant to current and long-term U.S. technology and security needs, including science-based stockpile stewardship, the National Ignition Facility, and new energy, environmental and health-care technologies. The Directorate conducts research and development in the areas of high explosives, composites and polymers, ceramics, corrosion, surface science, chemical engineering, physical metallurgy, thermochemistry, and analytical and physical chemistry. C&MS also serves as a pool of experts for assignment to programs outside of C&MS such as LLNL's weapons program, laser program, and biotechnology programs. C&MS's multidisciplinary project teams, staffed with innovative and creative scientists drawn from many scientific disciplines, include chemists, physicists and material scientists who work in four main areas: analytical science, chemical science, isotope science, and materials science and technology.

CES is an integrated analytical and radioanalytical chemistry program focused on environmental needs. CES was formed in 1995 by merging two existing LLNL analytical chemistry operations into a single organization. The new organization was formed with a mission to "function like a business," meaning that it is responsible for producing or procuring its products for its customers at a competitive cost. A number of features of the CES operation are unusual within a government facility. Specifically, CES continually re-evaluates the make-buy decision for its products, and has constructed its funding source such that failure to perform results in a financial penalty to the group itself.

The mission of CES is to provide high quality analytical data in support of LLNL's environmental protection, monitoring, and remediation programs. Furthermore, this data must be timely, useful, and reliable. CES performs and procures chemical and radiochemical analyses on:

- Hazardous waste and treatment process waste
- Construction/Demolition debris
- Effluent (on-site retention tanks as well as sewer outflow)
- Swipes
- Air samples (filters, air moisture)
- Surface, rain, and ground waters
- Soil and sediment
- Biota
- Foodstuffs

In the execution of its mission, CES focuses on its customer's needs, with expert scientists serving as customer liaisons. It procures analytical services from commercial vendors as well as operating on-site analytical chemistry and radiochemistry laboratories. It provides technical experts for consultation with its clients. CES strives to continuously improve its operation to provide the most cost-effective, defensible data possible to its clientele.

Requirements and Design Goals

The requirements and design goals for STARS were that it would:

- provide fast response time
- be extremely user friendly

- make use of a robust GUI
- require a minimum of time for users to come up to speed
- have a consistent look and feel throughout the system
- make use of rapid prototyping
- be modular
- be easy to modify and extensible
- be constructed using sound software quality assurance principles
- provide external customer reuse
- support the CES Chain of Custody (COC) form
- address issues of compliance to state and federal regulations

With the GUI that can be produced using Windows4GL, a very intuitive system can be built. Screens can be designed which lead the user through the operation of the screen. For example, we haven't yet produced the user guide for STARS, nevertheless our users are fully utilizing all of the features which have been designed into the system. We were able to conduct brief user training sessions which brought the users to a level of competency on the system. Each training session took less than 30 minutes.

To maintain a consistent look and feel throughout STARS, we developed a GUI style guide. This was especially important since the system is being implemented by several developers. The guide includes standards for screen titles, fonts, font sizes, line widths, shading, button names and placements, dimming fields, error messages, colors, pop-ups, frame placement, field titles, data values, menu pull-downs, and default frame modes. Our focus was to standardize every aspect which impacts the look and feel of the system. Developers reference the style guide to ensure that frames they code are consistent with the frames coded by other developers.

The ability provided by Windows4GL to developers for rapid prototyping of user interfaces was helpful to us. Rapid prototyping brings the users into the development cycle and helps to ensure the all-important user buy-in for a new computer system. In addition, rapid prototyping allowed each module to be reviewed by the particular users who would be using it to perform their daily duties. Through rapid prototyping we were able to fairly easily adapt our interface design to changing user requirements and priorities.

When design change requests were made later in the software lifecycle, we were able to draw on the modular nature of our database design and ease of modification with Windows4GL. For instance, we were able to add a new sample login screen where there had previously been none in the design. A sample login screen for one area of the organization had been designed and was approximately 90% completed when the new requirement for the second login screen became a high priority. Drawing on the features of Windows4GL, we were able to use a single frame for more than one screen. In addition, we were able to use the ability to disable fields by dimming them or making them invisible, while making others enabled, based on the different requirements for each login area. These features provided us with the flexibility we needed to minimize the number of frames and the amount of code that was required for the system.

The software quality assurance (SQA) principles that we employed in producing STARS served as a foundation for creating a system accepted by the user community. To ensure the production of a quality system, we:

- gather requirements from users and then produce system requirements specifications with detailed functional descriptions
- produce prototypes of user interfaces
- hold review sessions and walkthroughs with the pertinent users
- document the screen functions
- employ peer code reading by designated members of the development team after a screen is implemented. This is to reduce the number of bugs encountered while executing both unit and integrated test suites.
- employ software configuration management mechanisms, after screens are released, to control and prioritize our software maintenance process

Opportunities for the external reuse of the system are being researched. Two on-site programs have looked at the system. The Mixed Waste Management Facility planned to use the system for its process analytical laboratory. The sample login portion of the system would be reused almost in its entirety. Modifications to be made were in the area of dynamic definition of new sample analyses. Another on-site project which is in need of a customizable system is interested in using the STARS modules for sample tracking, bottle tracking, analysis reporting and archival of analysis data. These modules will be very easily ported to the new project. The design of the STARS table structures are robust enough so that most of the modifications required would be in the user interface. The International Atomic Energy Agency is also evaluating STARS for potential use as a laboratory information management system at its analytical facility. In this instance, the database independence of CA-OpenROAD will be required.

System Configuration

The database server is a four processor SPARCserver-1000 with 640Mb of RAM and 18Gb of disk space. The operating system is Sun Solaris 2.5. Most users log into a Solbourne computer running SunOS 4.1.3 and connect to STARS via X-terminals, or PCs or Macs running X-emulation software. We found that most users would rather have just one desk top computer to serve all of their computing needs. For users on the Macs, we have chosen version 5.1 of the eXodus emulation package available from White Pine Software. On the PCs, our users are running Microsoft WindowsNT and version 4.1.1 of the Exceed emulation package available from Hummingbird Communications Ltd. Ethernet provides the building network backbone while FDDI provides the building to building connections. All printers are UNIX queues and available from anywhere on the network. Barcoding is provided from Sigma Plus8 barcode printers and laser printers loaded with label stock. Lantronix EPS1 print servers are set up as queues allowing even the serial barcode printers to be networked. The vast majority of the analytical instruments are connected to the network via the PCs which are attached to the instruments for data acquisition (see Appendices B & C). Instrument computers are a diverse set. They include PCs, VAX Workstations, HP Vectra Controllers and HP Workstations.

System Load and User Base

Current projections are that STARS will process approximately 3000-4000 samples per year. This is limited by the number of samples submitted to CES by its customers. Other analytical laboratory consolidations at LLNL may increase the sample load to 70,000 samples per year. Each sample has an average of 8 analyses requested. STARS has 60 permanent tables. Approximately 30 screens support data inserting, updating and retrieval in STARS. We have, at present, thirty reports which users may select from a menu. STARS has been in production since December 3, 1995. The size of the STARS production database is 41Mb and it is growing at approximately 3Mb per month. At present (May 1996) there are approximately 35 users of STARS who access data daily. Our user base consists of technicians, chemists, quality control personnel, clerical staff, and management staff. Educational backgrounds range from high school diplomas to Ph.D.'s. Their familiarity with computers ranges from nearly computer illiterate to superusers.

Performance and Scaling

Given our present system configuration and sample load, the performance of our information system is not an issue. We have a high-performance machine which has enough physical memory (640Mb) to load both the operating system and CA-Ingres executables and database into memory which maximizes performance. Also, we have dedicated this machine solely for our use, thereby eliminating any contention for system resources from other user groups and applications. In addition, we do not expect our LIMS to become a very large database. We estimate that if our sample load increases by a factor of 20 in the future, our system performance would not degrade. We could, of course, perform additional CA-Ingres database tuning, should an increased sample load make it necessary.

STARS Context

STARS interfaces with several external entities as illustrated in the Context Diagram below (Figure 1).

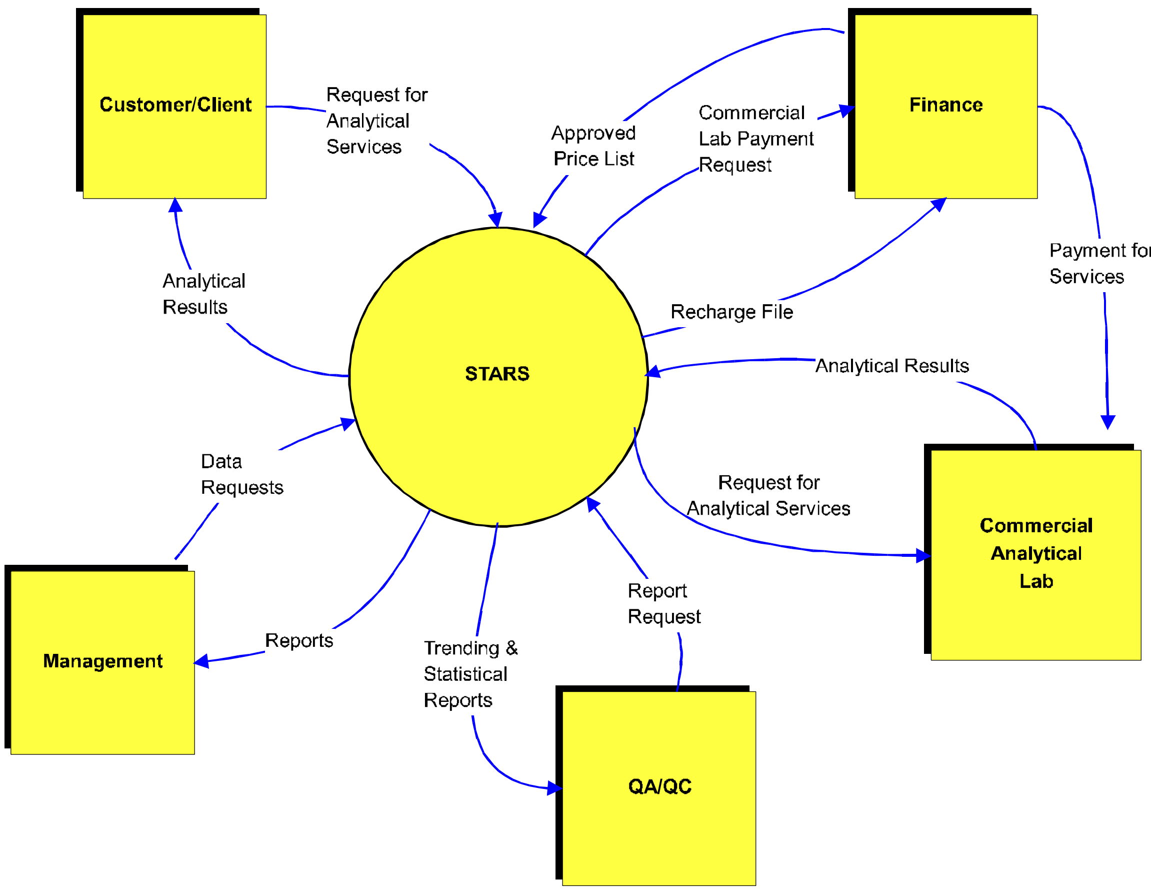


Figure 1 - STARS Context Diagram

System Implementation

STARS is comprised of six major functional areas: Sample Tracking, Cost Recharge, Bottle Tracking, Chemical and QA/QC Batching, Data Acquisition, and Data Reporting. These areas were designed as a whole to maintain system continuity. This proved to be valuable in obtaining business rules from a global perspective. For example, our requirements and design work uncovered a situation where a given piece of information was being used by three different groups in CES: the shipping department, the login department, and the billing department. Each group used the information differently without knowing about the use by the other groups. We were able to present a global perspective of this issue to management. In turn, management was able to make decisions to resolve the conflicting interpretation and the use of the information both operationally and in the software system. In contrast to the design process, implementation was accomplished through a phased approach which allowed us to concentrate on one functional area at a time. A phased implementation approach provides the ability to release portions of the system to the users in an incremental fashion. This approach maintains a high level of both user satisfaction and interest.

Our Sample Tracking functions provide the backbone of the system and consist of screens for logging in samples, updating samples, viewing samples as logged into the system, displaying of sample and analysis status, recording receipt of analytical reports, recording sample completion and selecting reports from a robust reports menu.

Many of these Sample Tracking screens were designed with the purpose of achieving maximum efficiency when doing data entry in a GUI system. For instance, when designing the COC and Sample Login screen (Figure 2), we made the layout look as close to the actual COC form (Appendix A) as possible. The user enters all of the COC header information first, skipping over the fields which require interaction with a mouse, such as option fields. Next the user keys the sample information. When the keyboard entries are completed, the mouse is used to select the analyses and any other fields requiring mouse interaction before clicking the Save button. In a highly keyboard intensive screen, the speed of data entry is degraded when the user must stop, remove a hand from the keyboard, grab the mouse and click on an area of the screen then go back to typing. It is worth noting that, in the previous version of Windows4GL, we were able to tab to and arrow down an option field which allowed the user to bypass the use of the mouse. Unfortunately, after one of the Windows4GL maintenance releases, we lost this ability and hope this feature will be available again in OpenROAD.

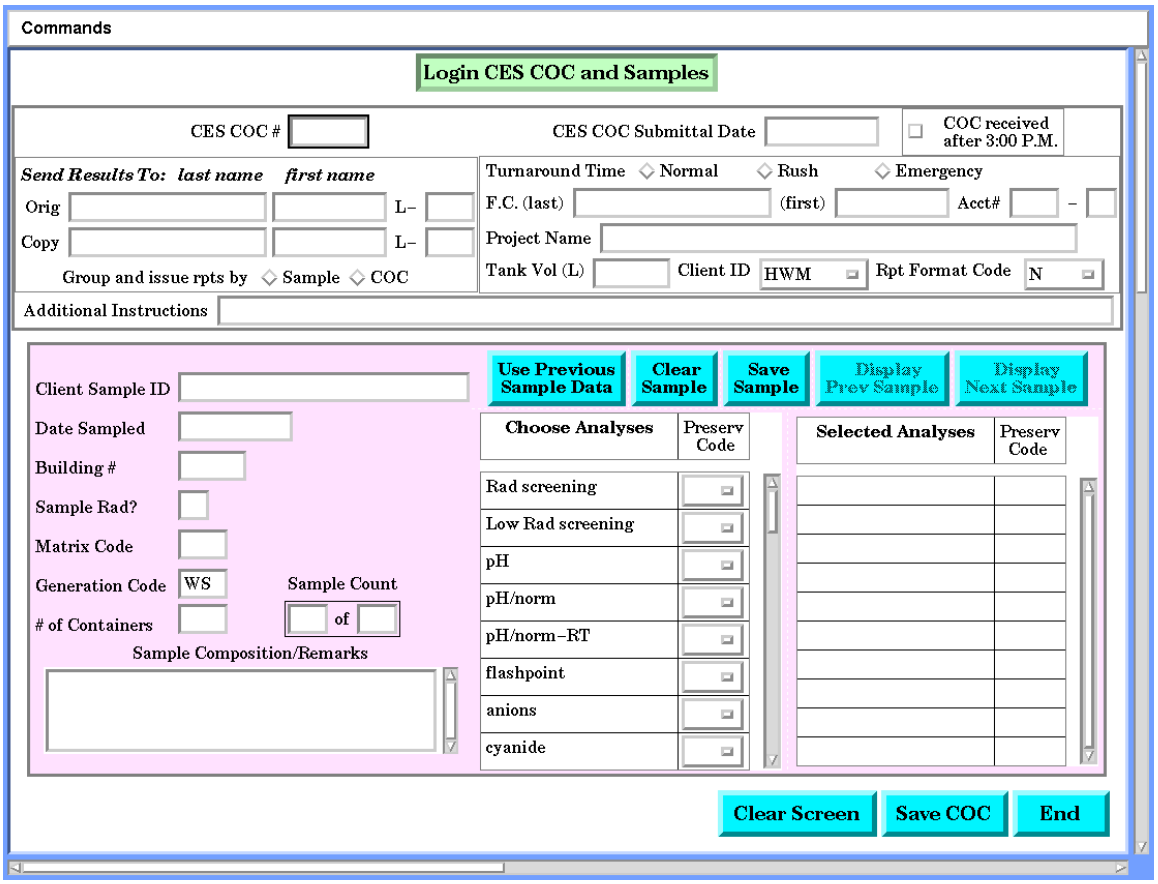


Figure 2 - Login CES COC and Sample Screen

Another useful feature in the design of this screen is that the user can enter multiple samples and their analyses into an array and cycle through the list of entered samples to modify data before saving the entire COC to the database tables. Also, for the times when many of the samples are the same, we provide a button, “Use Previous Sample Data,” that allows the user to copy the data from the last array element onto the screen.

Another strength of STARS has been its recharge module. CES operates as a full cost recovery organization. The CES recharge system is wholly founded on activity based costing. At Lawrence Livermore National Laboratory this is a leading edge endeavor. Most LLNL organizations are allotted a substantially fixed sum of funding with which to operate their programs. Their budgets are fixed throughout the fiscal year. CES must, in order to remain viable, fully recover its operating costs, through recharging client programs for the services provided to them by CES. This recharging effort had previously been done with paper records, Excel spreadsheets and macros. The non-relational aspect of Excel introduced problems for CES in accurately billing for its services which aggravated the inefficiency of the manual paperwork. We were able to design and implement an integrated recharge system which tracks sample completion, calculates charges based on a number of factors, prepares a billing file, and electronically transmits the billing file to the LLNL finance department.

The predecessors of CES found that they were experiencing difficulties brought about by losing or misplacing sample bottles. Using barcode readers and sample identifier labels with preprinted barcodes, we have implemented a tracking system for sample bottles. We have also integrated the production of worklists to the bottle tracking. Bottles are scanned in to areas where the chemical analysis is to take place. This triggers the production of worklists for the bench chemists. In addition, it allows us to pinpoint the location of any bottle in the system at any given time. We provide automatic reports which flag bottles that have remained in an area for an inordinate amount of time. A feature not found in the commercial products is the ability to link actual bottles to one or more analyses. The screen we designed to meet this need is illustrated in Figure 3.

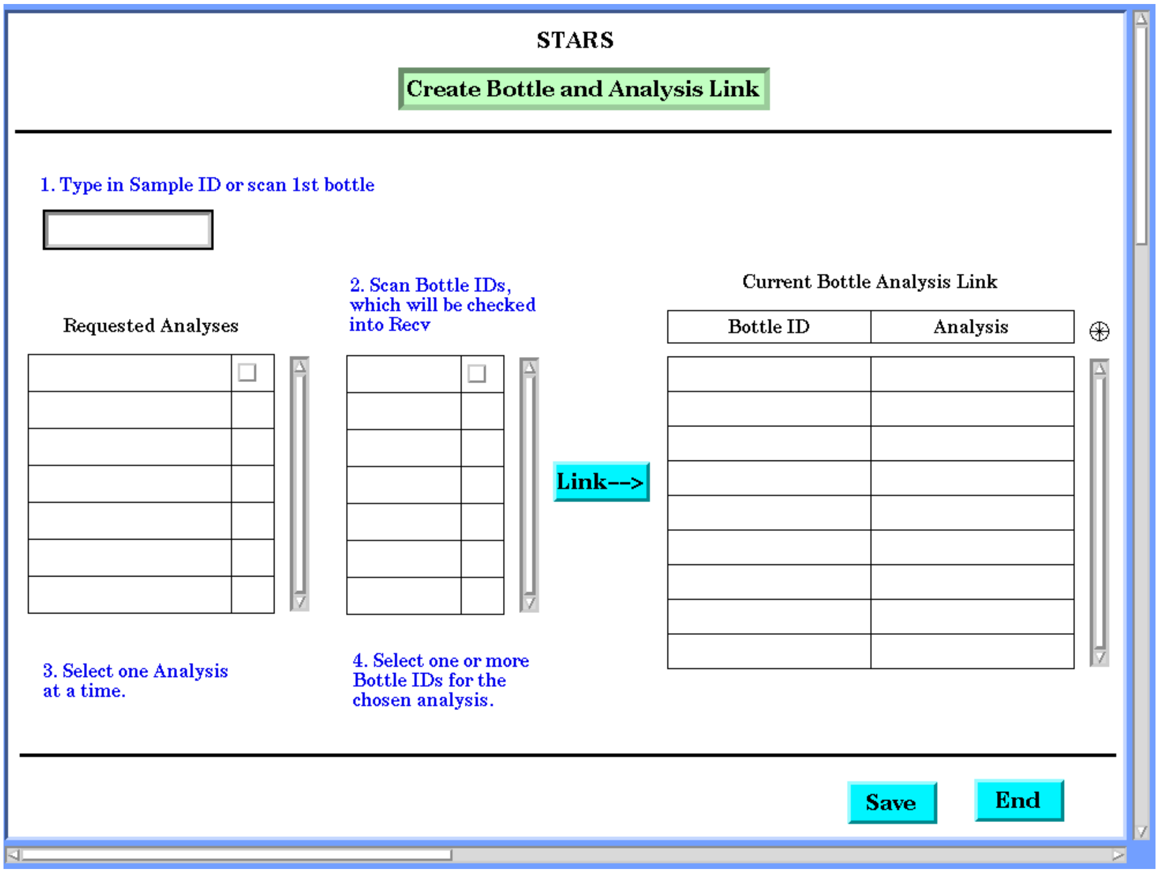


Figure 3 - Create Bottle and Analysis Link Screen

We are able to link a single bottle to many analyses or link one analysis to several bottles. We are also able to know if there are spare bottles of a sample, in case a bottle is broken and the sample lost. The ability for the user to view what linkages they have made on the right side of the screen has positively affected data accuracy.

A module closely related to the bottle tracking portion of the system is our Shipping module. This module, which is still in the design phase, will facilitate the selection of analyses that will be sent to off-site commercial laboratories. Samples can be shipped off-site for a variety of reasons. Samples may require analyses which CES does not perform. Shipping can also occur when load balancing is necessary for CES to meet turnaround times. If an analytical instrument is down for maintenance or repairs, samples may be shipped. The system keeps track of which analyses are currently being performed off-site. Once specific analyses are flagged, we inform the shipping personnel which samples have been logged in and need to be sent out. Through use of the barcode readers, these samples are read to create a shipment of samples to a specific commercial laboratory. This includes creating proper shipping documents. In creating the shipment, we use data from other portions of the system to track the level of radioactivity of a sample, if any, and the type of bottle being sent and any preservatives. This data is critical to ensure adherence to Department of Transportation regulations on shipping hazardous and radioactive materials. The new STARS shipping module will closely integrate and complement the recharge module for off-site analyses and the bottle tracking module.

For analytical laboratories, tracking chemical and QA/QC batches is important for providing defensible data results. Using barcode readers and sample identifier labels with preprinted barcodes, we were able to design a single generic batching screen which is used by all areas of the Laboratory Operations group and the analytical portions of the Sample Management Operations group of CES. We made use of Windows4GL option fields to provide the flexibility needed for each analytical area.

STARS data acquisition is diverse. Some manufacturers of analytical instruments provide code for data reduction. From these instruments, we upload the final data into our tables. Other analytical instruments merely capture raw data. We employ 3GL code to perform needed data reduction, then store the final data in STARS. For yet other instruments, we designed data input screens in which chemists and technicians enter data manually. This area is one of the most challenging since the data can come from so many diverse systems. Appendices B and C display the analytical instruments and the hardware that holds the data before it is transferred up to the database via the network.

Regardless of the means for obtaining the result data from the instruments, we also are developing a generic robust and extensible data reporting module that will handle the reportable data from all of the analytical areas of CES as well as commercial electronic data deliverables. For many of the areas, this involves performing data reduction on raw data to convert it to reportable data. In this instance, we need to perform calculations based on specific analytical parameters and client requirements.

When designing our system, we keep in mind the principle that the system is only as good as the ability of the users to get the data back out in a useful form. We designed into the system methods for viewing the data both on-line and through hardcopy reports. One of our most frequently used screens by each of the various categories of users is the sample status screen (See Figure 4). This screen provides several avenues to the data by allowing the user to retrieve data by CES COC number, the unique CES Sample ID or even by the client's own identifier which may not be unique. In many instances, the client will call with questions and our users have several methods available to them to look up the status of the item in question. If the user enters a COC number, the client sample ID is dynamically loaded with all of the samples on that COC. The user can then view the list of options and select any sample to display.

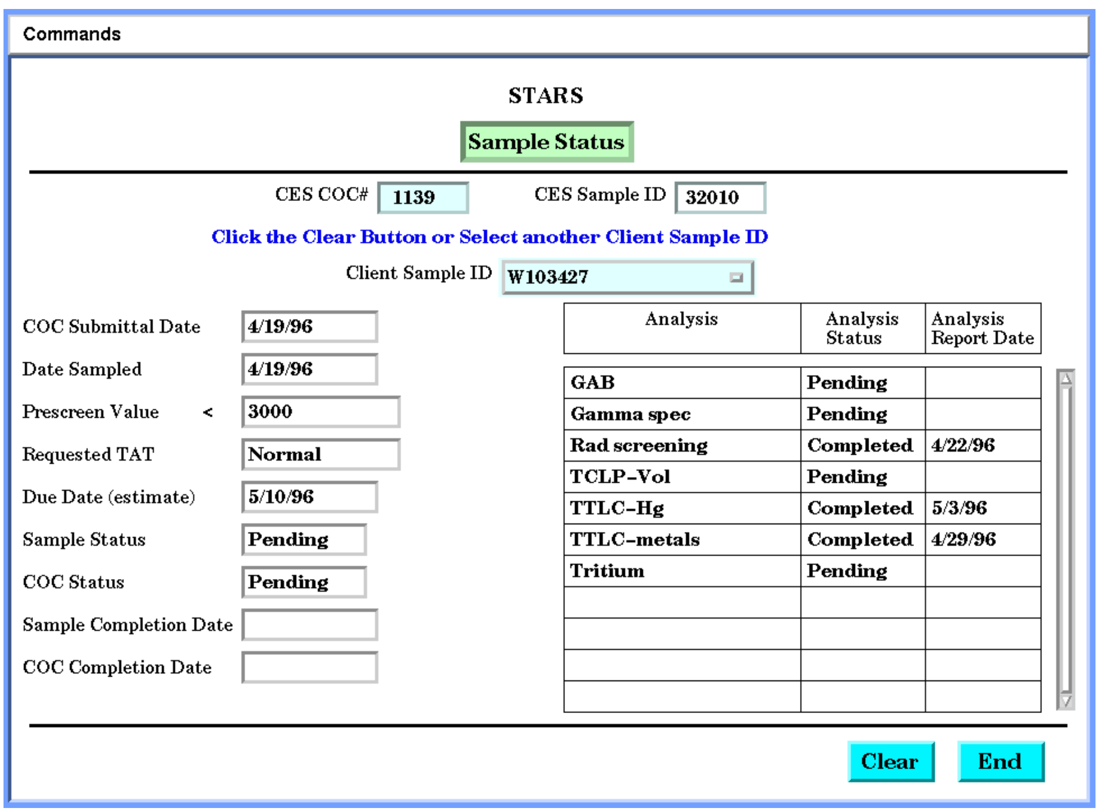
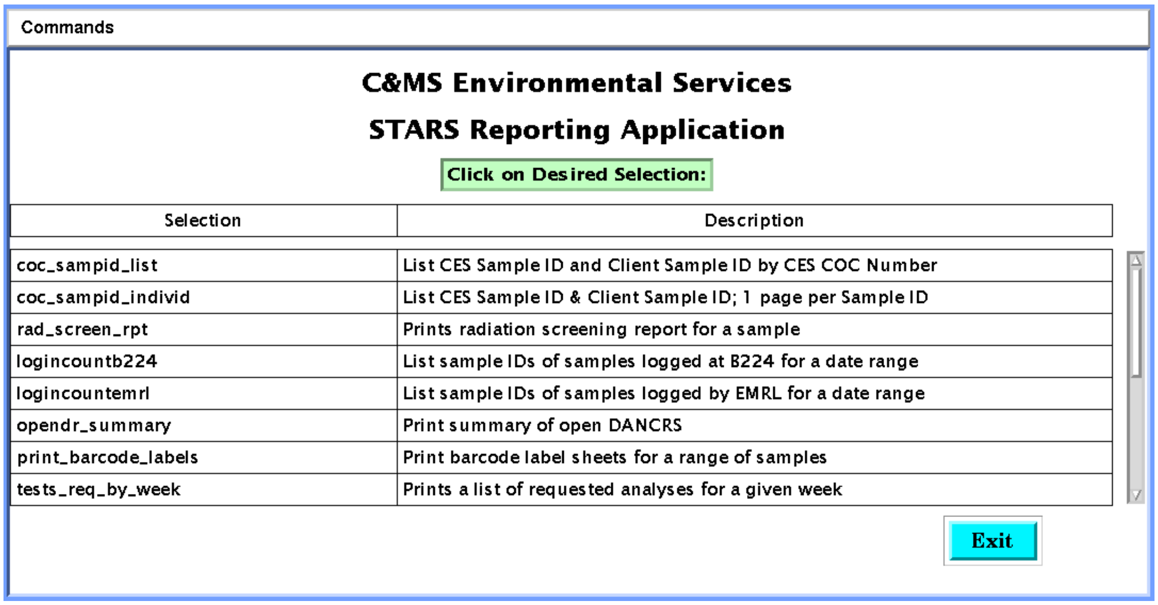


Figure 4 - Sample Status Screen

An alternate method for retrieving data is via the STARS reports menu (Figure 5). The selection table field on the reports menu is dynamically loaded from a permanent database table. In this way, when we add new reports to our menu, we are not required to modify any code. Likewise it is our standard procedure to dynamically load all option fields in screens from permanent database tables, again to prevent unnecessary code modification.



Selection	Description
coc_sampid_list	List CES Sample ID and Client Sample ID by CES COC Number
coc_sampid_individ	List CES Sample ID & Client Sample ID; 1 page per Sample ID
rad_screen_rpt	Prints radiation screening report for a sample
logincountb224	List sample IDs of samples logged at B224 for a date range
logincountemrl	List sample IDs of samples logged by EMRL for a date range
opendr_summary	Print summary of open DANCRS
print_barcode_labels	Print barcode label sheets for a range of samples
tests_req_by_week	Prints a list of requested analyses for a given week

Figure 5 - STARS Report Selection Menu Screen

On the Reports Menu, after the user selects a specific report, a generic pop-up screen (Figure 6) is displayed which prompts the user to enter any required parameters and to change the destination printer and the number of copies to print.

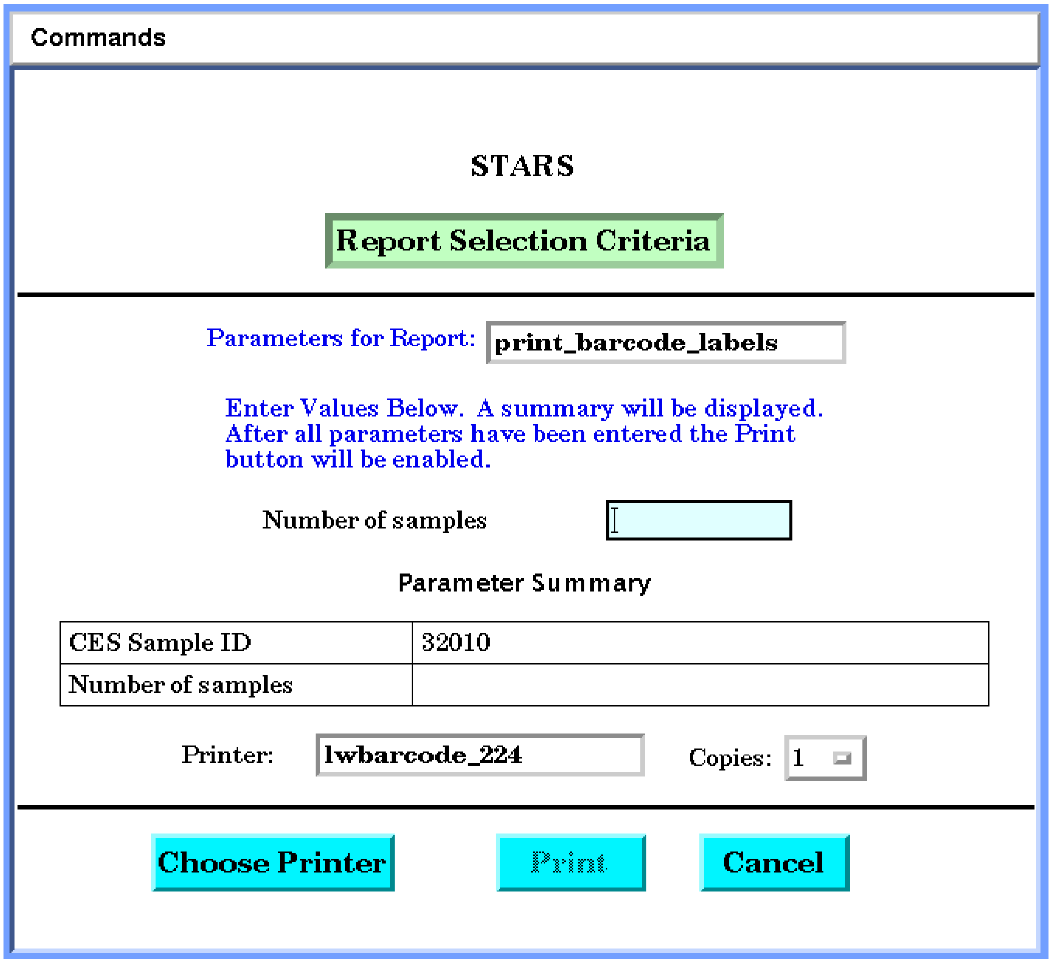


Figure 6 - Report Selection Criteria Screen

To implement this scheme, we employed the use of two separate tables. The first table, rpts_menu_selections, populates a table field with a list of reports the user can select. The second table is called the v_rpt_parameters table. This table contains a record for each input parameter required by a given report. Table v_rpt_parameters does not have an entry for those reports not requiring parameters. See Figure 7 for the table structures.

Rpts_Menu_Selection	
* applic_name	varchar(32) nn nd
* frame_name	varchar(32) nn nd
* report_name	varchar(32) nn nd
. report_desc	varchar(60) nn nd
. display_sort	integer2 nn nd

V_Rpts_Parameters	
* applic_name	varchar(32) nn nd
* frame_name	varchar(32) nn nd
* report_name	varchar(32) nn nd
. param_num	integer2 nn nd
. param_type	varchar(10) nn nd
. param_name	varchar(24) nn nd

Figure 7 - Reporting Table Structures

When the Report Selection Criteria screen is displayed for the user, they will be prompted to enter one parameter at a time. Once all the parameters are entered, the user has the option of going back to modify any of the values by clicking on the Parameter Summary table field. Only after all the parameters are entered is the print button made available to the user by changing the field bias from dimmed to changeable. The dynamic nature of this screen has greatly simplified the steps necessary to release newly created reports to the user community. Releasing a new report merely requires entries into the above tables.

Third Party Products

To produce reports directly from the database with desktop publishing quality, we use the DBPower reporting tool available from Db-Tech, Inc. This product has a GUI report builder tool for creating the simpler reports and a 4GL for the more complex reports. We have found the quality of these report layouts to be far superior to the character based reports from other vendors. Figure 8 is a sample report demonstrating the use of varying fonts, styles, line drawings and reverse video.

C&MS Environmental Services
Radioanalytical Worksheet

CES Sample ID: **30904**
CES COC # 1911

RUSH !!!

Tests Requested:

X **Alpha/Beta**
___ **Tritium**
___ **Gamma**
___ **Special**

Sample Matrix: **Aqueous**
Building: **222**
Date Sampled: **01-Mar-1996**
Sample Login Date: **01-Mar-1996**
Rad Screening (dpm/ml): **136**
Batch ID: ____________

Sample Composition / Remarks:
ethylene glycol

Alpha/Beta Worksheet

MANUAL DIGESTION			MICROWAVE DIGESTION		
Replicate/Rerun ID	____	____	Replicate/Rerun ID	____	____
Aliquot Volume (ml)	____	____	Carousel Position #	____	____
Gross Weight (gm)	____	____	Process	____	____
Tare Weight	____	____	Gross Weight (gm)	____	____
Net Weight	____	____	Density (organics)	____	____
Density (organics)	____	____			
Plating:			***Plating:***		
Flask Volume (ml)	____	____	Flask Volume (ml)	____	____
Plated Volume (ml)	____	____	Plated Volume (ml)	____	____
Gross Planchet (mg)	____	____	Gross Planchet (mg)	____	____
Tare Planchet (mg)	____	____	Tare Planchet (mg)	____	____
Quality Control:			***Quality Control:***		
QC Sample ID	____	____	QC Sample ID	____	____

Comments: ____________

Analyst: ____________ *Date Completed:* ____________

03-Apr-1996 18:18:25 Rpt: hwrlwksheets

Figure 8 - Example report generated with DBPower

Another third party product which has added value to STARS is Statit. Statit is a statistical package from Statware which we are using to create statistical analyses and process control charts. This product has a GUI tool for building graphs directly from the database. We use UNIX cron jobs to execute Statit command files and SQL files to produce color business graphs and charts which are uploaded and available for viewing on the Web. Figure 9 is an example of the useful types of business graphs which can be easily produced with Statit.

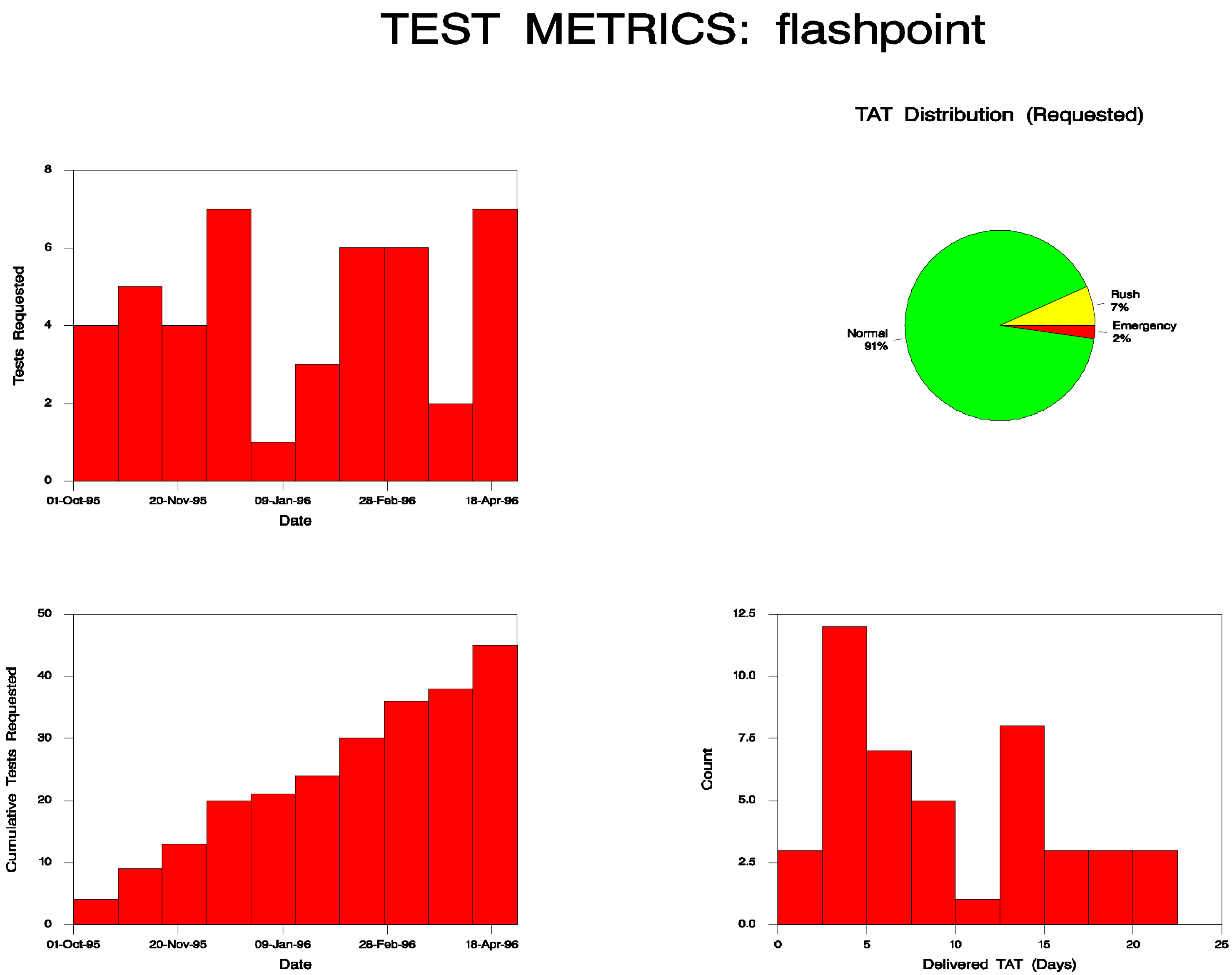


Figure 9 - Business graph produced using Statit

Future Plans

Our future direction is to continue to streamline and facilitate the operations of CES. Our vision is to upgrade and introduce full automation in the following areas:

- upgrade our Windows4GL applications to CA-OpenROAD
- upgrade from CA-Ingres to CA-OpenIngres
- employ the use of database procedures to control table access and improve performance
- implement features of Knowledge Management
- make appropriate portions of our system available through the web
- provide remote login of samples as an option to our clients
- integrate the production of all analytical reporting; This may include employing client/server applications on the PCs which are connected directly to the analytical instruments. Our plan is to fullyintegrate the data acquisition with the use of CA-OpenIngres/Net.
- integrate the bench chemistry instruments which includes balances, simple meters, etc.
- perform analytical data calculations and data reduction with updated 3GL code
- implement time stamping of our updates, to prevent concurrency issues

Summary

In conclusion, we have found development of a LIMS in Windows4GL to be very satisfying. The product, STARS, has been well received by the user community. Additionally, it has improved business practices and efficiency in CES. The CES management staff has seen increased personnel productivity since STARS was released. We look forward to upgrading to CA-OpenROAD and taking advantage of its many improved and innovative features to further enhance STARS.

CES Chain-of-Custody and Analytical Instructions COC-

Send Results to:

Original: ______________________ L-________

Copy: ______________________ L-________

Group and issue reports by: Sample ☐ COC ☐

Turnaround Time: ☐ Normal ☐ Rush ☐ Emergency

Field Contact: ____________________________ LLNL Account #: __________ -___

Project Name: ____________________________ Report Format Code: __________

Tank Volume : ______________ liters Client ID: ____________________________

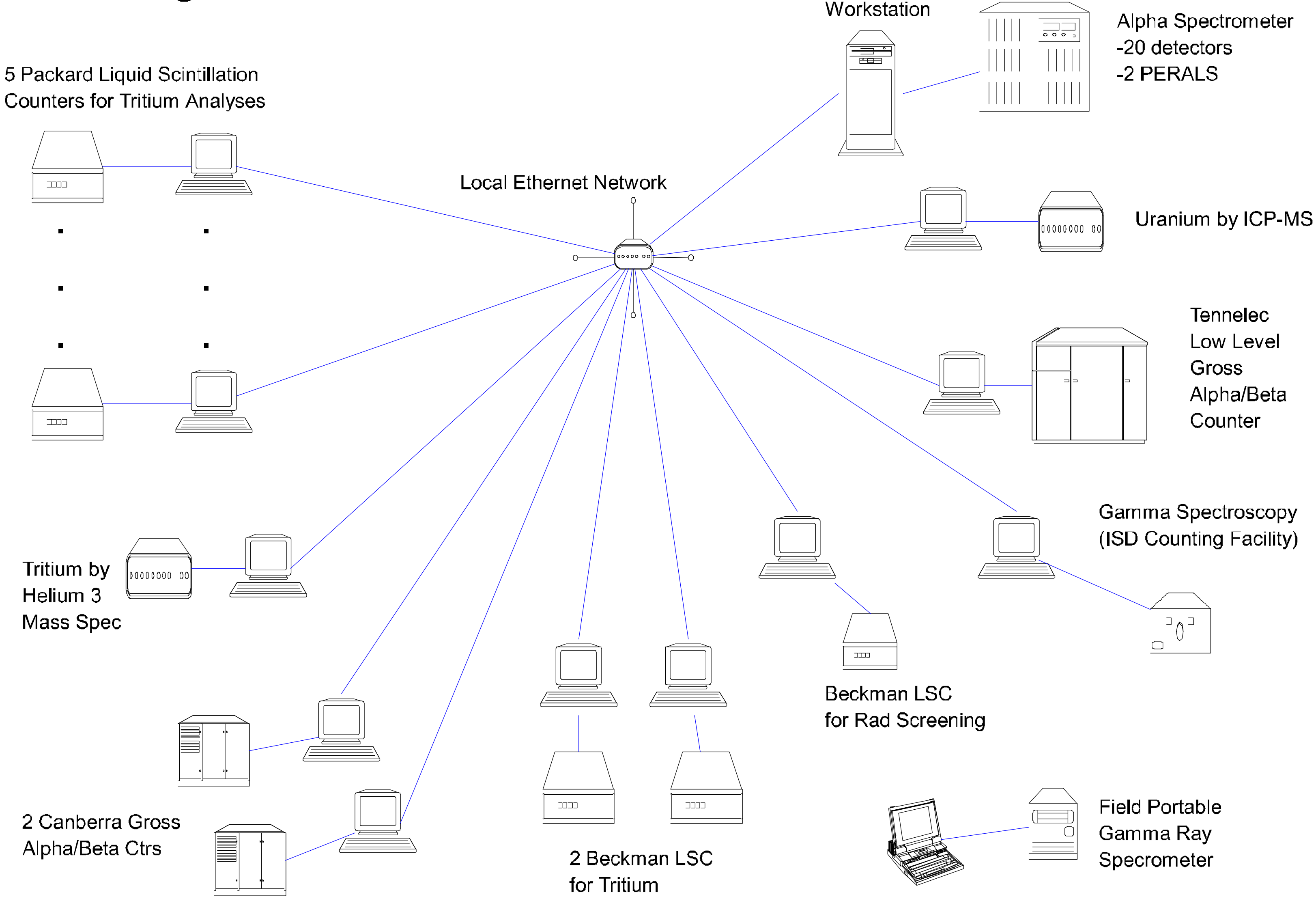
Sample Identification	Date Sampled	Building	Sample Rad (Y/N)	Matrix Code	Generation Code	# Containers	Tests / Preservation Codes								Additional Instructions: Sample Composition / Remarks
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															

Signature	Employee #	Signature	Employee #	Date	Time
Relinquished by:		Received by:			
Relinquished by:		Received by:			
Relinquished by:		Received by:			

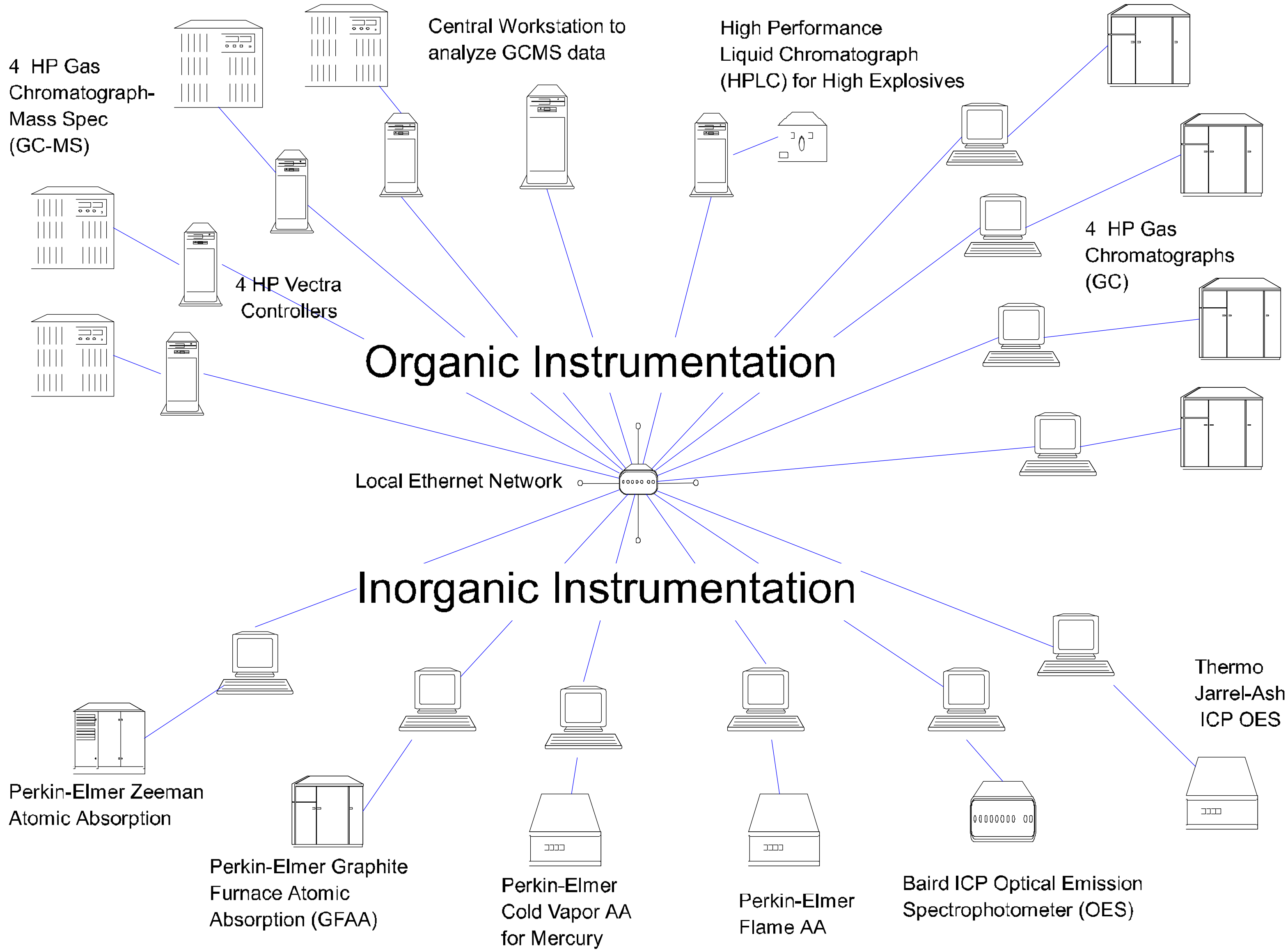
Revision 1.0 22Sep95 CES phone # (510) 424-4127 ELAP Certifications #1554 & 1983 See back of form for codes and additional instructions

Appendix B - Local Area Network Diagram of Radiological Instruments

Radiological Instrumentation



Appendix C - Local Area Network Diagram of Organic and Inorganic Instruments



Appendix D - Terms and Acronyms

AA	Atomic Absorption
C&MS	Chemistry and Materials Science
CES	C&MS Environmental Services
COC	Chain of Custody
cron	UNIX process scheduling utility
FDDI	Fiber Distributed Data Interface
GC	Gas Chromatograph
GC-MS	Gas Chromatograph-Mass Spectrometer
GFAA	Graphite Furnace Atomic Absorption
HPLC	High Performance Liquid Chromatograph
ICP-MS	Inductively Coupled Plasma Mass Spectrometer
ICP OES	Inductively Coupled Plasma Optical Emission Spectrophotometer
ISD	Isotope Science Division
LIMS	Laboratory Information Management System
LLNL	Lawrence Livermore National Laboratory
LSC	Liquid Scintillation Counter
MS	Mass Spectrometer
PERALS	Photon Electron Rejecting Alpha Liquid Scintillation
QA/QC	Quality Assurance/Quality Control
SQA	Software Quality Assurance
STARS	Sample Tracking, Analysis and Reporting System
TAT	Turnaround Time